

# **2013 Title 24 Impact Assessment on Lighting Programs Use Cases**

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## NONRESIDENTIAL RETROFIT / ALTERATION / MODIFICATION-IN-PLACE

### 1. RETAILER INCORPORATING SCREW BASE LIGHTING PRODUCTS AND MEDIUM PIN BASED LED TUBE PRODUCTS

A retail customer with a sales floor of 2,500 sf will be replacing existing 60 watt incandescent lamps with screw-base LED lamps and linear fluorescent lamps with internally driven LED tubes in existing luminaires. In addition, the customer will be installing an LED retrofit kit in recessed cans over the sales floor.

#### 1) What code requirements will be required of the project

The retailer would not need to demonstrate compliance with the code as these measures are not considered an alteration or a luminaire modification in place. The installation of screw-based products does not trigger compliance requirements. The standards do not recognize any screw-in product even if it reduces the consumption of the luminaire. The reason for this is that the screw-in product can always be unscrewed later on and an incandescent lamp inserted later on. Thus the current approach treats any screw in retrofit as having unreliable savings and insufficient for compliance with building standards. As a project that does not trigger code compliance, no additional controls, switching or shut-off strategies would be required.

The rationale applied in the case of screw-based CFL products is the same for integrated and non-integrated CFL lamps. Integrated CFL lamps contain their own drivers, and can be directly connected to a line-voltage socket through any type of incandescent base. Integrated LED lamps that fit into any type of incandescent luminaire never qualify as high efficacy luminaires for compliance with the Standards because they can be replaced with incandescent lamps. Most low-voltage LED track spotlights are nonintegrated lamps. These lamps never qualify as high efficacy luminaires because they could easily be replaced with incandescent lamps.

LED tubes with integrated drivers intended to replace fluorescent lamps in existing luminaires also do not trigger the 2013 Standard.

### 2. BANK RETROFIT/ALTERATION WITH ADDED LPD ALLOWANCE

The lighting system in a bank is being upgraded and triggered code by the definition of a standard alteration. The connected load will be smaller than the existing lighting system and the area of the bank is to remain the same. The lobby has a chandelier which is considered 'ornamental' lighting. The project will use the Area Category Method for compliance (and claim an additional allowance for the ornamental lighting in the lobby) because this method allows them a higher total wattage as compared to the Complete Building Method. Though it potentially qualifies for additional ornamental allowance, there is no ornamental lighting planned in the Financial Transactions area. The project does not qualify for any lighting power density adjustment factors.

#### 1) What is the initial Lighting Power Density requirement (before adding ornamental lighting allowances)?

Primary Function Area	LPD	Area	Allowed Watts
Corridors	0.6 W / ft <sup>2</sup>	800 ft <sup>2</sup>	480

Entry Lobby	1.5 W / ft <sup>2</sup>	300 ft <sup>2</sup>	450
Financial Transactions	1.2 W / ft <sup>2</sup>	1,200 ft <sup>2</sup>	1,440
Managers Office	1.0 W / ft <sup>2</sup>	200 ft <sup>2</sup>	200
Totals		2,500 ft <sup>2</sup>	2,570

2) What is the additional ornamental lighting wattage allowance for a chandelier with 5 screw based sockets each rated at 50 W lamps in a 300 ft<sup>2</sup> bank entry lobby?

- a. The wattage based on the task space is  $0.5 \text{ W/ft}^2 \times 300 \text{ ft}^2 = 150 \text{ W}$ . The wattage based on actual rated design wattage of the chandelier is 250 W. The wattage allowance for the chandelier is the smaller of the two values, or 150 W.
- b. The chandelier can still be installed but the additional 100 watts needs to be offset elsewhere in the total allowable watts for the space applying for a permit. The difference does not need to be made up in the entry lobby itself. Total allowable wattage for the whole space will be 2,720 (2,570 plus 150 watts specifically allotted to ornamental lighting).

3) What lighting control requirements would be required for the bank?

- a. Area Controls
- b. Multi-Level Controls: Multi-level control must be realized within individual luminaires and using switches to control different luminaires does not qualify as multi-level control. The type of multi-level control required varies depending on the installed LPD. Higher LPD requires more levels of control, while improved LPDs results in less stringent control requirements.
  - i. If installed wattage is  $\leq 2,312\text{W}$  or 85% of the allowable 2,720 W, then bi-level control is permitted with one level falling between 30-70 percent of design lighting power.
  - ii. If installed wattage is  $> 2,312\text{W}$ , the requirement varies depending on lighting source as defined by the control requirements. Depending on fixture type, continuous dimming or up to four levels of control may be required with multi-level output occurring at the fixture level.

Additionally, altered or modified luminaires will need to comply with one of the following control strategies

- Manual dimming
  - Lumen maintenance – defined as “a strategy used to provide a precise, constant level of lighting from a lighting system regardless of the age of the lamps or maintenance of the luminaires”
  - Tuning – defined as “the ability to set maximum light levels at a lower level than full lighting power”
  - Automatic daylighting controls
  - Demand responsive controls
- c. Shutoff Controls
  - d. Daylighting Control
    - i. Installed wattage  $\leq 2,312\text{W}$ . No day lighting control required.
    - ii. Installed wattage  $> 2,312\text{W}$ . Day lighting control required.
  - e. No demand response controls required as the foot print of the space remained the same and the wattage of the lighting system did not increase.

- 4) Alternatively what is the ornamental lighting wattage allowance for an integrated LED chandelier rated at 50 W (Not retrofit screw in lamps) installed in a 300 ft<sup>2</sup> bank entry lobby?
- a. If the LED products are integrated into the original design of the chandelier, then the allowable wattage is based on the lower of the task space calculation of  $0.5 \text{ W/ft}^2 \times 300 \text{ ft}^2 = 150 \text{ W}$  or the actual design watts of 50 W. As the wattage allowance for the chandelier is the smaller of the two values, the allowance is 50 W.
  - b. The additional 100 watts as calculated by the task space calculation is not transferrable to other aspects of the lighting system. Total allowed power in the bank is 2,620 W (2,570W minus the extra 100W of unused ornamental lighting power). 50 watts out of the 2,620 is specifically allotted to ornamental lighting (in this case the chandelier).

### 3. PARTIAL-ON OCCUPANT CONTROL IN CONFERENCE ROOMS RECEIVED LPD ADJUSTMENT FACTOR (PAF)

As part of a scheduled re lamp and ballast throughout the entire floor of a building, a 600 ft<sup>2</sup> conference room will incorporate partial-on occupant control. The conference room is in an interior space so there is no available daylight. The project in total will re ballast more than 40 fixtures so the 2013 Standard is triggered due to modification in place rules.

1. What is the initial Lighting Power Density requirement in the conference room?
  - a. The conference room itself does not need to meet LPD requirements on its own though the project as a whole will be required to do so.
  - b. The 600 ft<sup>2</sup> conference room contributes  $1.4 \text{ W / ft}^2$  for an initial allotment generated from the conference room of 840 W.
  - c. An additional  $0.5 \text{ W / ft}^2$  is available for ornamental lighting, which if used would total 300 W. This additional allotment cannot be used for general lighting purposes
2. At a high level, what lighting controls would be required?
  - a. Area Controls
  - b. Multi-Level Controls
    - i. Multi-level control requirement based on luminaire type (See Use Case 2 bullet 3 of this document for additional explanation)
    - ii. Modified or altered luminaires in spaces using more than 85 percent of allowable LPD for the space will need to comply with one of the following control strategies
      - Manual dimming
      - Lumen maintenance – defined as “a strategy used to provide a precise, constant level of lighting from a lighting system regardless of the age of the lamps or maintenance of the luminaires”
      - Tuning – defined as “the ability to set maximum light levels at a lower level than full lighting power”
      - Automatic daylighting controls
      - Demand responsive controls
  - c. Shutoff Controls
  - d. Day lighting Control, if more than 85 percent of allowable wattage is used
  - e. Demand response controls, not required

3. What 2013 Standards benefit would the project receive assuming partial-on occupancy control was installed?
  - a. Note partial-on occupancy control is not otherwise required by the 2013 Standard
  - b. The equipment is installed in a conference room and that is one of the Lighting Power Density Adjustment Factor (PAF) eligible areas for this control type. Other areas include any area  $\leq 250$  square feet enclosed by floor-to- ceiling partitions; any size classroom, conference or waiting room.
  - c. It qualifies for a PAF of 0.20 as per Table 140.6A in the Standard
4. If the partial-on occupant controls 8 linear fluorescent fixtures in a room but does not control the 5 incandescent 100 W lamps that are also in the area. How is the PAF applied?

Fixture	Quantity	Fixture Wattage	Connected Load Wattage	PAF	PAF Equation	2013 Standards Recognized Wattage
Fluorescent	8	52	416	0.2	$416 \times (1-0.2)$	332.8
Incandescent	5	100	500	0	$500 \times (1-0.0)$	500
Total			916			832.8

5. Conclusion
  - a. With addition of partial-on occupant controls, the conference room stays within its allowance. Allowance 840 W as compared to 832.8 W recognized by the 2013 Standards. The conference room actually contributes 7.2 W to the allowable wattage for other areas in the space.
  - b. Without the partial-on occupant controls, the conference room would have exceeded its allowance. Allowance 840 W as compared to 916 W connected load. Other areas in the space would have had to install 96 W less than their allotment for the space as a whole to comply.

#### 4. MULTI-LEVEL SWITCHING REQUIREMENTS – RETROFIT CASE

In a 40,000 square foot office building, the primary fixture type is a 3-lamp 2-foot by 4-foot troffer equipped with T8 lamps and electronic ballasts. The building owner is considering the following retrofit from a 3-cove reflector to a 2-cove reflector, and 2 F32T8 lamps and new CEE ballasts (0.87 ballast factor). Additionally the space has a limited number of pin based compact fluorescent fixtures that will remain the same. The project would trigger the code requirements for a luminaire modification in place since more than 40 fixtures and 10% of fixtures will be retrofit.

The existing lighting power density was 1.1 watts/sf, with a total of 494 3-lamp troffers. With all fixtures being replaced, the post-retrofit lighting power density (excluding other credits) with fixtures of 55 watts each would be 0.69 W/sf ( $[494 \text{ troffers} \times 55 + 20 \text{ CFL cans} \times 26 \text{ W}] / 40000$ ). The allowable lighting power density for the space is 0.75 W/sf. After completing the retrofit, the resulting LPD would be 92% (0.68 W/sf / 0.75 W/sf) of the allowable LPD for code compliance.

1. In general, what is the control requirements required for the troffers?
  - a. As a result, the following controls requirements would be triggered, affecting the retrofitted fixtures:
    - i. Area controls

- ii. Multi-level controls
    - iii. Shutoff controls
    - iv. Day lighting controls
  - b. Each modified or altered luminaire must also be controlled by at least one of the following methods:
    - i. Manual dimming
    - ii. Lumen maintenance
    - iii. Tuning
    - iv. Automatic daylighting
    - v. Demand responsive lighting
2. With regards to the troffers, what are the specific control requirements for multi-level switching?
- a. The ballast/lamp configuration of the troffers must be capable of meeting the multi-level switching requirements for fluorescent fixtures described in Table 130.1-A, which mandates 4 stepped levels of on and off, or a fully dimming fixture.

Minimum one step in each range:				Stepped dimming; or continuous dimming; or switching alternate lamps in each luminaire, having a minimum of 4 lamps per luminaire, illuminating the same area and in the same manner
20-40 %	50-70 %	80-85 %		

3. In general, what is the control requirements required for the CFL Fixtures?
- a. The CFL fixtures were not part of the retrofit project so they were not modified in place and there are no control requirements for these fixtures.
  - b. If the CFL fixtures were part of the modification in place, the same general control requirements that were applicable to the troffers would be applicable to CFL fixtures.
4. If the 26 W CFL fixtures were part of the modification in place, what are the specific multi-level control requirements?
- a. Continuous dimming from 20-100 percent
  - b. Modified or altered luminaires need to comply with one of the following control strategies
    - Manual dimming
    - Lumen maintenance – defined as “a strategy used to provide a precise, constant level of lighting from a lighting system regardless of the age of the lamps or maintenance of the luminaires”
    - Tuning – defined as “the ability to set maximum light levels at a lower level than full lighting power”
    - Automatic daylighting controls
    - Demand responsive controls
5. Where are the full multi-level requirements found?
- a. 2013 Standard section 130.1(b)
  - b. 2013 Standard table 130.1-A

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## 5. FIXTURE REWIRING AND REPLACEMENTS – TRIGGERS

There are 60 lighting fixtures in an existing office space. The facility is replacing and relocating five fixtures without increasing the connected lighting load or rewiring any of the fixtures.

In order to determine code requirements, the project needs to be evaluated under Lighting System Alteration, Luminaire Modification in Place, and Lighting Wiring Alterations criteria.

1. Which Standards requirements must we comply with?
  - a. Because less than 10% of the existing luminaires in the enclosed space are affected, and the installed lighting power is not being increased, the space may maintain its existing installed lighting power and controls provisions.
    - i. It is not a Lighting System Alteration because fewer than 10% of the fixtures are affected, an increase in lighting power does not result, and there is no indication that the project is part of a general renovation of the space.
    - ii. It is not a Luminaire Modification in Place because fewer than 10% of the fixtures are affected and the total number of fixtures does not total 40 or more
    - iii. It does not trigger Lighting Wiring Alteration because no new wiring is being installed
2. Relocating a fixture does not trigger a lighting wiring alteration if existing wiring is used. What does trigger a lighting wiring alteration?
  - a. Adding a circuit feeding luminaires.
  - b. Modifying or relocating wiring to provide power to new or relocated luminaires.
  - c. Replacing wiring between a switch or panelboard and luminaire(s).
  - d. Replacing or installing a new panelboard feeding lighting systems.
3. If in the example above the five replaced luminaires are also receiving power from new electric wires, which Standards requirement must be complied with?
  - a. This triggers a wiring alteration and mandatory controls requirements are triggered for the affected fixtures regardless of the percentage or number of fixtures.
  - b. Any fixtures directly impacted by the lighting wiring alterations shall meet the applicable requirements of the Standards including:
    - i. Indoor lighting controls
      1. Area controls
      2. Multi-level controls
        - Multi-level control requirement based on luminaire type (See Use Case 2 bullet 3 of this document for additional explanation)
        - Modified or altered luminaires in spaces using more than 85 percent of allowable LPD for the space will need to comply with one of the following control strategies
          - Manual dimming
          - Lumen maintenance – defined as “a strategy used to provide a precise, constant level of lighting from a lighting system regardless of the age of the lamps or maintenance of the luminaires”
          - Tuning – defined as “the ability to set maximum light levels at a lower level than full lighting power”



- Automatic daylighting controls
    - 3. Demand responsive controls Shutoff controls
    - 4. Day lighting controls
  - ii. Acceptance Testing and Certificates of Installation.
4. If instead of 5 fixtures, 20 fixtures were being replaced and relocated, and rewired, then which Standards requirements must be complied with?
- a. Because more than 10 percent of the fixtures are being replaced (20 fixtures/ 60 fixtures) and the fixtures are being relocated and new wiring run, the project qualifies as an alteration and not a modification in place. As an alteration, compliance is triggered once 10 percent of the fixtures are affected regardless of the numbers of total fixtures.
  - b. The total lighting power in the space must not exceed the lighting power allowance for open offices, of 0.75 W/ square foot.
  - c. Mandatory control requirements for the affected fixtures would be required.
    - i. If the fixture replacement results in a LPD >85% of the allowed LPD ( $0.75 * .85 = 0.6375$  W/sf), what control measures must the new fixtures in the space meet?
      - 1. Area controls
      - 2. Multi-level controls
        - Multi-level control requirement based on luminaire type (See Use Case 2 bullet 3 of this document for additional explanation)
        - Modified or altered luminaires in spaces using more than 85 percent of allowable LPD for the space will need to comply with one of the following control strategies
          - Manual dimming
          - Lumen maintenance – defined as “a strategy used to provide a precise, constant level of lighting from a lighting system regardless of the age of the lamps or maintenance of the luminaires”
          - Tuning – defined as “the ability to set maximum light levels at a lower level than full lighting power”
          - Automatic daylighting controls
          - Demand responsive controls
      - 3. Shutoff controls
      - 4. Day lighting controls
      - 5. Demand response capability – required only if the alteration changes the area of the enclosed space or increases lighting power
    - ii. If the installed power is 85% or less of the lighting power allowance of 0.75W/ square foot, what control measures must the new fixtures in the space meet?
      - 1. Area controls
      - 2. Shutoff controls
      - 3. Two level lighting control, or multi-level control. Shall have at least one step between 30 and 70% of design lighting power in a manner providing reasonably uniform illumination
  - d. If the fixtures were not being relocated, they would qualify as a luminaire modification in place and a 40 fixture minimum would be required prior to code requirements being triggered.

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## 6. LUMINAIRE MODIFICATIONS IN PLACE-FLUORESCENT LAMP BALLAST REPLACEMENT –

There are 60 lighting fixtures in an existing office space. The facility is replacing 20 fixtures with fixture kits that only required disconnecting the existing luminaires and reconnecting the new luminaires.

1. What code requirements should be applied?
  - a. Disconnecting old and reconnecting new luminaires without adding new wiring is subject to modification-in-place rules. Less than 40 fixtures are being modified so the space may maintain its existing installed lighting power and controls provisions.
2. If in the example above, 50 fixtures were being replaced with fixture kits or new fixtures, which Standards requirements must be complied with?
  - a. Because more than 40 fixtures are being modified, the altered lighting must not exceed the lighting power allowance for open offices, of 0.75 W/ square foot.
  - b. Mandatory control requirements for the affected fixtures would be required.
    - i. If the fixture replacement results in a LPD >85% of the allowed LPD ( $0.75 \times .85 = 0.6375$  W/sf), what control measures must the new fixtures in the space meet?
      1. Area controls
      2. Multi-level controls
      3. Shutoff controls
      4. Day lighting controls
      5. Demand response capability – required only if the alteration changes the area of the enclosed space or increases lighting power
    - ii. If the installed power is 85% or less of the lighting power allowance of 0.75W/ square foot, what control measures must the new fixtures in the space meet?
      1. Area controls
      2. Shutoff controls
      3. Two level lighting control, or multi-level control. Shall have at least one step between 30 and 70% of design lighting power in a manner providing reasonably uniform illumination
    - iii. While LPD calculations are based on the entire space, the control requirements are only applicable to the 50 directly affected fixtures.

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## 7. ADDING LIGHTING FIXTURE TO AN EXISTING LIGHTING SYSTEM

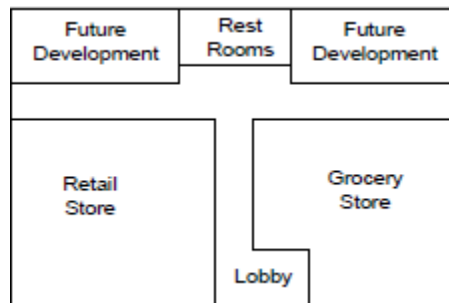
All light fixtures are being replaced in one enclosed room of a commercial tenant space. The entire tenant space currently has a total of 25 light fixtures but will receive an additional eight new light fixtures. The total number of fixtures after the project will increase to 33.

1. How much lighting power is allowed for the new lighting?
  - a. The lighting power allowed for the eight new lighting fixtures in this non-residential space is evaluated as part of the entire system. Instead of evaluating the eight new fixtures separately, the eight new fixtures plus the 25 modified light fixtures are evaluated together.
2. Is this an alteration or a modification in place?
  - a. The eight new fixtures being added to the existing system makes this an alteration as it will require new wiring to bring power to the new fixtures.

- b. The lighting power density for the space must be determined and an allowance calculated. The Lighting Power Allowance will be determined inclusive of any LPD allowances for special loads.
- c. Together the 33 fixtures must be within the calculated allowance. The load will be calculated based on the input wattage of the lamp ballast combination as published in manufacturer's catalogs and determined by independent testing labs and consistent with UL 1598. The load will be adjusted for any eligible LPD Adjustment Factors.
- d. Mandatory control requirements for the affected fixtures would be required.
  - i. If the fixture replacement results in a LPD >85% of the allowed LPD ( $0.75 \times .85 = 0.6375$  W/sf), what control measures must the new fixtures in the space meet?
    1. Area controls
    2. Multi-level controls
    3. Shutoff controls
    4. Day lighting controls
    5. Demand response capability – required only if the alteration changes the area of the enclosed space or increases lighting power
  - ii. If the installed power is 85% or less of the lighting power allowance of 0.75W/ square foot, what control measures must the new fixtures in the space meet?
    1. Area controls
    2. Shutoff controls
    3. Two level lighting control, or multi-level control. Shall have at least one step between 30 and 70% of design lighting power in a manner providing reasonably uniform illumination

## 8. MULTI TENANT BUILDING

A 10,000-ft<sup>2</sup> multi-use building is to be built consisting of a 500 ft<sup>2</sup> main entry lobby, a 2,000 ft<sup>2</sup> corridors and restroom, 3,000 ft<sup>2</sup> grocery store, 2,500 ft<sup>2</sup> retail, and 2,000 ft<sup>2</sup> future development.



1. What is the base allowed lighting power under the area category method?

Space	LPD	Area	Allowed Watts
A) Main Entry	1.5 W/ft <sup>2</sup>	500 ft <sup>2</sup>	750
B) Corridors and Restrooms	0.6 W/ft <sup>2</sup>	2,000 ft <sup>2</sup>	1,200
C) Grocery Sales	1.2 W/ft <sup>2</sup>	3,000 ft <sup>2</sup>	3,600
D) Retail Store	1.2 W/ft <sup>2</sup>	2,500 ft <sup>2</sup>	3,000
TOTAL		8,000 ft <sup>2</sup>	8,550

With 2,000 ft<sup>2</sup> for future development

2. Shortly after construction the retail store decides to renovate the lighting system. What is the maximum allowable watts for the retail store?
  - a. As in the above example, determine the total square feet of the retail store (2500 feet)
  - b. As in the above example multiply the allowed LPD (1.2 W/ft<sup>2</sup>) X 2500 = 3000W (base allowance)
  - c. Determine the maximum allowed display and accent allowance by multiplying the retail store's 2500 feet by 0.3 W/ft<sup>2</sup> (Footnote 6 from Table 5-5 of the Standards) = 750W
  - d. Determine the maximum allowed ornamental lighting allowance (for chandeliers) by multiplying the retail store's 2500 feet by 0.2 W/ft<sup>2</sup> (Footnote 6 from Table 5-5 of the Standards) = 500W
  - e. Add the 3000W base plus 750W for display and 500W for ornamental = 4250W
  - f. The maximum allowed watts for this retail store, under the area method, is 4,250W or 1.7 W/ft<sup>2</sup>  
NOTE: The allowed maximum is usually somewhat less than the theoretical maximum of 1.7 W/ft<sup>2</sup> as the display/accent lighting and ornamental lighting components are "use-it-loose it" with the lower luminaire lighting power becoming the allowed power. Also for the added power to be allowed, it must be in addition to general lighting and must use the appropriate luminaires for the task as defined the luminaires

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## 9. EMERGENCY LIGHTING

A 25,000 sf commercial property is completing a full building fixture replacement and installing wireless lighting controls.

1. In commissioning of the controls system, what are the controls standards that must be considered by the contractor?
  - a. Area Lighting Controls: all luminaires must be controlled by manual on and off lighting controls, with an exception of 0.2 W/sf for emergency egress, but only during times when the building is typically occupied. The following conditions must be met for this exception:
    - i. The area is a designated emergency egress area on plans and specifications
    - ii. The control switches for the egress lighting are not accessible to unauthorized personnel.
  - b. Shut off controls: emergency egress lighting is no longer an exception to applicable shut off requirements.
    - i. All lighting in the building must be shut off when the building is unoccupied.
    - ii. The exception to this rule is for office buildings, where up to 0.05 W/sf of lighting may be continuously on in areas of emergency egress, as shown on plans and specifications.

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## 10. STAIRWELL RETROFIT

A multi-level commercial property is replacing the existing stairwell fixtures as part of a building-wide lighting fixture replacement project.

1. What controls standards must be met in the stairwells?
  - a. Lighting installed in stairwells must be controlled by occupancy sensors that switch to 50% of full power or less, or up to 60% in the case of areas where the installed lighting power is <80% of the allowed LPD under the Area Category Method. The occupant sensing controls shall be capable of

turning the lighting fully on only in the separately controlled space, and shall be activated from all designed paths of egress.

- b. Fixtures must meet the standards for shutoff controls, where any of occupancy sensors, time switch control, or other building system control shall be capable of shutting off all of the lighting when the space is typically unoccupied. If the property is an office building, up to 0.05 W/sf of continuous lighting power would be exempted if the stairwell is part of a designated emergency egress area. Stairwells in high-rise residential buildings and hotels/motels are also provided an exemption from the shutoff requirements, but must still be controlled by occupancy sensors.

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## 11. WAREHOUSE DAY LIGHTING CONTROLS

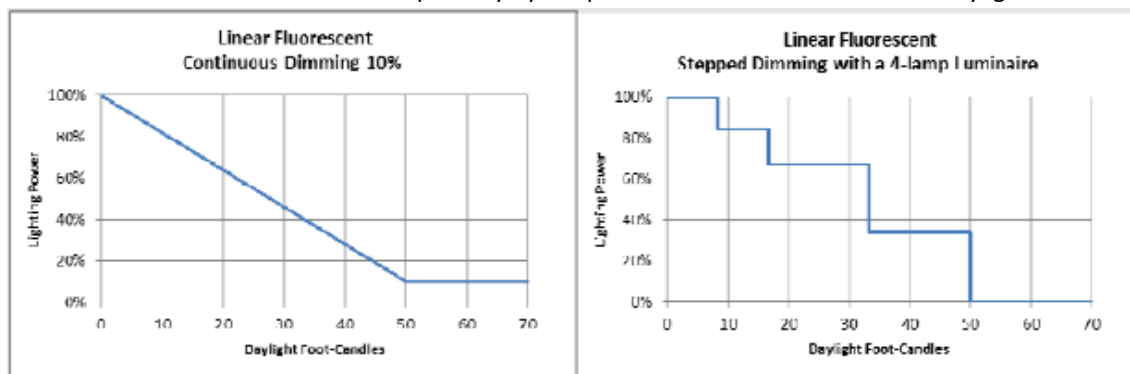
A warehouse with a 40,000 square feet area and 30 foot tall ceiling (roof deck) has existing skylights. They intend to retrofit their T5 linear fluorescent lighting system and the retrofitted lighting system makes use of all of the lighting power allowance.

1. Do new skylights need to be installed to meet day lighting requirements?
  - a. As a retrofit project, new skylights are not required by the Standard.
  - b. If this were new construction or an addition, minimum daylighting requirements might apply depending on the project dimensions.
2. Does the retrofit project need to incorporate daylighting controls?
  - a. For projects that use more than 85 percent of their lighting power allowance, the Standards require that automatic daylighting controls be installed.
  - b. This project is using 100 percent of the lighting power allowance so controls are required.
3. What are the daylighting zones?
  - a. **SKYLIT DAYLIT ZONE** is the rough area in plan view under each skylight, plus 0.7 times the average ceiling height in each direction from the edge of the rough opening of the skylight, minus any area on a plan beyond a permanent obstruction that is taller than the following: A permanent obstruction that is taller than one-half the distance from the floor to the bottom of the skylight. The bottom of the skylight is measured from the bottom of the skylight well for skylights having wells, or the bottom of the skylight if no skylight well exists.  
For the purpose of determining the skylit daylit zone, the geometric shape of the skylit daylit zone shall be identical to the plan view geometric shape of the rough opening of the skylight; for example, for a rectangular skylight the skylit daylit zone plan area shall be rectangular, and for a circular skylight the skylit daylit zone plan area shall be circular.
  - b. **PRIMARY SIDELIT DAYLIT ZONE** is the area on a plan directly adjacent to each vertical glazing, one window head height deep into the area, and window width plus 0.5 times window head height wide on each side of the rough opening of the window, minus any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor
  - c. **SECONDARY SIDELIT DAYLIT ZONE** is the area on a plan directly adjacent to each vertical glazing, two window head heights deep into the area, and window width plus 0.5 times window head height wide on each side of the rough opening of the window, minus any area on a plan beyond a permanent obstruction that is 6 feet or taller as measured from the floor
4. What are the control requirements?
  - a. All Skylit Daylit Zones and Primary Sidelit Daylit Zones shall be shown on the plans.

- b. Luminaires in the Skylit Daylit Zone shall be controlled separately from those in the Primary Sidelit Daylit Zones.
  - c. Luminaires that fall in both a Skylit and Primary Sidelit Daylit Zone shall be controlled as part of the Skylit Daylit Zone.
  - d. Automatic Daylighting Control Installation and Operation. For luminaires in daylight zones, automatic daylighting controls shall be installed and configured to operate according to all of the following requirements:
    - i. Photosensors shall be located so that they are not readily accessible to unauthorized personnel, and the location where calibration adjustments are made to automatic daylighting controls shall not be readily accessible to unauthorized personnel.
    - ii. Automatic daylighting controls shall provide functional multi-level lighting having at least the number of control steps specified by the Standard.
5. What are the multilevel requirements for linear fluorescent?
- a. A minimum of 4 control steps are needed. These steps are identified as:
    - i. 1 - 20-40%; 2 - 50-70%; 3 - 80-85%; 4 - 100%
  - b. This can be achieved in one of three ways, using:
    - i. A. Continuous dimming - the photocontrol gradually dims all luminaires in the daylight zone in response to the available daylight.
    - ii. B. Stepped dimming with a 4-lamp luminaire - The required control steps can be achieved using a 4-lamp fixture and with two lamps powered by an ON/OFF

Stage	On/Off Switching Ballast - power level	2-Stepped Dimming Ballast - power level	Result
1 - Full ON	100%	100%	100%
2	100%	67%	84%
3	100%	33%	67%
4	0%	67%	34%
5 - Full OFF	0%	0%	0%

- iii. Switching alternate lamps in each luminaire, having a minimum of 5 lamps per luminaire. Here the lamps may be tandem-wired such that power to each of the 5 lamps can be controlled separately by the photocontrol based on available daylight.



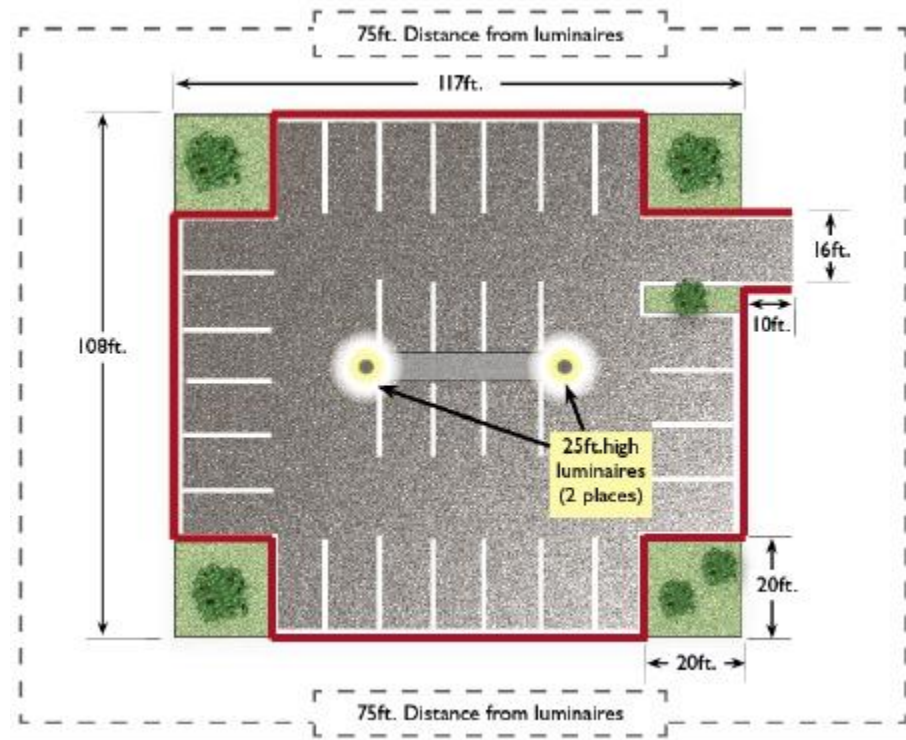
## 12. WIRELESS LIGHTING CONTROLS

A building owner is installing a new wireless lighting control system while otherwise keeping the lighting system intact.

1. Does the project trigger the need for code compliance?
  - a. This scenario is not addressed well within the code.
  - b. By a strict read of the code, it would be triggered. An Alteration is defined by the Standards as follows any change to a building's water-heating system, space-conditioning system, lighting system, or envelope that is not an addition;
  - c. A wiring alteration is also defined by the code but would not trigger full compliance. A wiring alteration would trigger:
    - i. Indoor lighting controls (Area, Multi-Level, Automatic
    - ii. Shut-OFF, Daylighting, and Demand Responsive).
    - iii. Acceptance Testing and Installation Certificates.

## 13. PARKING LOT AND HARDSCAPE LIGHTING

A building owner is renovating the parking lot illustrated below. The lot has two luminaires that are mounted at a height of 25 ft. The lot is located in an urban area as defined by the U.S. Census Bureau. The poles are 40 feet apart. Both of the existing HID fixtures will be replaced with LED retrofit kits.



1. Do LPD requirements need to be met?
  - a. Yes LPD requirements need to be met because more than 10 percent of the fixtures are affected.

2. What is the maximum allowable size of the parking lot?
  - a. The poles are 40 feet apart and 25 ft high, so using the 10 times mounting height rule, the illuminated area can be as large as 250 ft by 290 feet (10 x 25 ft in the shorter dimension, and 10 x 25 ft + 40 ft in the longer dimension). The boundary of this maximum illuminated area extends beyond the edges of the parking lot as well as the entrance driveway, so the entire paved area is considered illuminated. Areas outside the boundary of the paved area, beyond property lines, or obstructed by structures are not considered illuminated.
3. What is the illuminated hardscape area?
  - a. The landscaped island in middle and peninsula below the entrance driveway are less than 10 ft wide, so they are included as part of the illuminated area, but not part of the hardscape perimeter.
  - b. The landscaped cutouts (20 x 20 ft) in the corners of the parking lot are bound by pavement on only two sides so they are not included.
4. What is the allowed lighting load?
  - a. As the lot is located in an urban area all allowances are based on lighting zone 3 and found in Table 0-8 (Table 140.7-A in the Standards).
  - b. The allowance is calculated based on three sources. Zone 3 values are provided below:
    - i. Area: 0.090 W/ft<sup>2</sup>
    - ii. Linear: 0.60W/lf
    - iii. Initial: 770 W for the entire site.
  - c. The total paved area is 11,196 ft<sup>2</sup>. [(117 x 108 + 10 x 16 driveway) – 20 x 20 x 4 cutouts)].
  - d. The perimeter of the hardscape is 470 ft [(2 x (117 - 40) + (2 x (108 - 40) ft) + (8 x 20 ft) + (2 x 10 ft)].
  - e. Three allowances make up the total power allowance:
    - i. Area: The area wattage allowance is equal to 1,007.6 W (0.090 W/ft<sup>2</sup> x 11,196 ft<sup>2</sup>).
    - ii. Linear: The linear wattage allowance (LWA) is equal to 282 W (0.60W/lf x 470 lf).
    - iii. Initial: The initial wattage allowance (IWA) is fixed for zone 3 at 770 W for the entire site.
  - f. The total wattage allowance for the site of is 2,059.6 W (1,007.6 W + 282W + 770 W).
5. What controls are required?
  - a. Motion sensing for incandescent luminaires rated over 100 watts
  - b. Automatic controls to turn lighting OFF when daylight is available
  - c. Separate circuiting and independently controlled from other electrical loads by an automatic scheduling control
6. What other fixture/luminaire requirements exist?
  - a. Backlight, Uplight, and Glare (BUG) rating zonal lumen limits for luminaires ratings greater than 150 watts unless excluded by the code. BUG limits are used to control the amount of light that is not being directed towards the ground, and instead contributes to glare.
7. The parking lot is adjacent to a building that has 250W wall packs mounted on the side of the building. Do these wall packs have to meet the BUG zonal lumen limits?
  - a. It was determined that while the wall packs are also illuminating the façade of the building, their main purpose is for parking lot illumination.
  - b. Yes, these 250W wall packs will have to meet the zonal lumen limits because their main purpose is for parking lot illumination. Luminaire mounting methods or locations do not necessarily



determine the purpose of the illumination. Each luminaire must be appropriately assigned to the function area that it is illuminating, whether it is mounted to a pole, building, or other structure. Only wall packs that are 150W or less are not required to meet the Uplight and Glare limits in the Standard.

8. Can 250W, non-cut-off wall packs for building façade lighting be used?
  - a. Even though façade lighting is exempt from the zonal lumen limits, you cannot consider a traditional wall pack installation as façade lighting because most of the light from these luminaires will not illuminate the façade to which they are attached. Most 'wall pack' style luminaires do not direct the majority of the light exiting the luminaire onto the façade. Only wall packs that are 150W or less are not required to meet the Uplight and Glare limits in the Standard.

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## 14. PARKING GARAGE LIGHTING

A three level parking garage building is constructed such that daylight openings are found on the first and second level of the parking garage building and the third level of parking is uncovered or open to the sky. The building owner intends to replace existing linear fluorescent fixtures with LED fixtures on the first and second levels while existing pole mounted HID fixtures mounted on 18-foot poles are to be replaced by LED fixtures on the third level. The garage operates 24 hours a day. The stairwells serving the building will be retrofit from existing fluorescent lamps to LED tube replacements. Stairwells account for less than 10 percent of the total floor area.

1. What LPD requirements apply to the building lighting system?
  - a. The first and second level of the parking garage are treated as interior spaces
    - i. If prescriptive whole building method is used for compliance, allowable LPD is 0.2 watts per square foot
    - ii. If prescriptive area category method is used LPD varies depending on the area defined as parking area (0.14 watts per square foot), dedicated ramps (0.3 watts per square foot), daylight adaption zones (0.6 watts per square foot),
      1. Daylight Adaptation Zones shall be no longer than 66 feet from the entrance to the parking garage
    - iii. The stairwells do not need to comply with code as installing LED tubes in existing fluorescent fixtures does not trigger code requirements.
  - b. The third level of the parking structure needs to comply with the Parking Lot and Hardscape lighting requirements as detailed in the previous use case example.
2. What control requirements apply to the first and second level of the parking garage?
  - a. Area controls
  - b. Multi-level controls
    - i. By occupant sensing controls having at least one control step between 20 percent and 50 percent of design lighting power, and
    - ii. The occupant sensing controls shall be capable of automatically turning the lighting fully ON only in the separately controlled space, and
    - iii. The occupant sensing controls shall be automatically activated from all designed paths of egress.

- c. Day lighting controls: In a parking garage area having a combined total of 36 square feet or more of glazing or opening, luminaires providing general lighting that are in the combined primary and secondary sidelit daylight zones shall be controlled independently from the rest of the lighting by automatic daylighting controls, and shall meet the following requirements as applicable:
  - i. Automatic Daylighting Control Installation and Operation.. Automatic daylighting control shall be installed when the total combined general lighting power in the primary and sidelit daylight zones is equal to or more than 60 watts:
  - ii. Automatic daylighting controls shall have photosensors that are located so that they are not readily accessible to unauthorized personnel, and the location where calibration adjustments are made to the automatic daylighting controls shall not be readily accessible to unauthorized personnel.
  - iii. Automatic daylighting controls shall be multi-level, continuous dimming or ON/OFF.
  - iv. The combined illuminance from the controlled lighting and daylight shall not be less than the illuminance from controlled lighting when no daylight is available.
  - v. When the sidelit zones receive illuminance levels greater than 150 percent of the illuminance provided by the controlled lighting when no daylight is available, the controlled lighting power consumption shall be zero.
  - vi. Luminaires located in the daylight transition zone and luminaires for only dedicated ramps do not need to comply with daylighting control requirements.
  - vii. Primary and secondary zone can be controlled together in parking garages whereas they must be separately controlled in other spaces
  - viii. Daylighting controls in parking garages can be ON/OFF whereas for all other new interior spaces the control must be step switching or dimming
  - ix. When fully daylight, lighting in parking garages has to be turned all the way off whereas in other interior spaces the lights can consume up to 35% of full power.
- 3. What if Metal Halide replacement fixtures were being used on the first and second levels instead of LED fixtures?
  - a. Have a metal halide lamp plus ballast mean system efficacy of greater than 75 lumens per watt, (the lamp/ballast mean system efficacy is the rated mean lamp lumens at 40% of lamp life)
  - b. Metal halide luminaires shall be controlled by occupant sensing controls having at least one control step between 20 percent and 60 percent of design lighting power.
  - c. All other provisions remain the same.
- 4. What control requirements apply to the third level of the parking garage?
  - a. Automatic controls to turn lighting OFF when daylight is available
  - b. Separate circuiting and independently controlled from other electrical loads by an automatic scheduling control
  - c. Motion sensing devices for luminaires mounted below 24 feet above ground that automatically reduce the lighting power of each luminaire by at least 40 percent, but not greater than 80 percent, auto-ON functionality when the area becomes occupied and no more than 1,500 watts of lighting power shall be controlled together with a single sensor

## RESIDENTIAL INTERIOR NEW CONSTRUCTION/ RETROFIT / ALTERATION

### 15. SCREW BASE LIGHTING PRODUCTS CFL OR LED

A home owner will be replacing existing 60 watt incandescent lamps with screw-base LED lamps. In addition, the customer will be installing an LED retrofit kit in recessed cans.

1. Is code compliance required?

- a. The home owner would not need to demonstrate compliance with the code as these measures are not considered an alteration or a luminaire modification in place. The installation of screw-based products does not trigger compliance requirements. The standards do not recognize any screw-in product even if it reduces the consumption of the luminaire. The reason for this is that the screw-in product can always be unscrewed later on and an incandescent lamp inserted later on. Thus the current approach treats any screw in retrofit as having unreliable savings and insufficient for compliance with building standards. As a project that does not trigger code compliance, no additional controls, switching or shut-off strategies would be required.
- b. The rationale applied in the case of screw-based products is the same for integrated and non-integrated lamps. Integrated lamps contain their own drivers, and can be directly connected to a line-voltage socket through any type of incandescent base. Integrated LED lamps that fit into any type of incandescent luminaire never qualify as high efficacy luminaires for compliance with the Standards because they can be replaced with incandescent lamps. Most low-voltage LED track spotlights are nonintegrated lamps. These lamps never qualify as high efficacy luminaires because they could easily be replaced with incandescent lamps.

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## 16. NEW FIXTURES IN KITCHENS

A residential home owner is making renovations to their existing kitchen that has six recessed incandescent cans. They are adding a new luminaire over the sink.

1. How do the residential lighting Standards apply to this case?

- a. The six recessed incandescent cans are unaffected and can remain in place.
- b. All new luminaires must be high efficacy until at least 50% of the total lighting wattage comes from high efficacy luminaires (§150.2(b)1 and §150.2(b)2).
- c. Note that requirement varies by room type.

A residential home owner is completely remodeling their existing kitchen and putting in an entirely new lighting system.

2. How do the residential lighting Standards apply to this case?

- a. As existing lighting fixtures are being removed and replaced by new fixtures, the existing equipment is not considered.
- b. The remodel is treated like newly constructed buildings.
- c. High efficacy luminaires must account for at least 50% of the total lighting wattage installed (§150.2(b)1 and §150.2(b)2).

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## 17. LIVING ROOM & DINING ROOM LIGHTING RETROFIT

A residential tenant is doing renovations to their living room and dining room that will include six new permanently installed luminaires. Also included in the project is a retrofit of two downlights with screw-based LED retrofit kits. Four other existing luminaires will remain untouched.

1. Does this project trigger code and if so, how?
  - a. All six of the new, permanently installed luminaires must be either high efficacy or be controlled by either dimmers or vacancy sensors.
  - b. The two screw-based LED retrofit kits do not need to meet code because they are not considered new permanently installed luminaires.
  - c. The 4 luminaires that are not part of the retrofit do not need to be addressed.